A case study illustration of the layout and support in an Indian coal mine with difficult roof condition where continuous miner is in operation

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A CASE STUDY ILLUSTRATION OF THE LAYOUT AND SUPPORT IN AN INDIAN COAL MINE WITH DIFFICULT ROOF CONDITION WHERE CONTINUOUS MINER IS IN OPERATION

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ABSTRACT: Coal is the most important source of energy. Coal India Limited (CIL), a public sector coal company of the Ministry of coal, has reported the highest ever production of 538.75 MT of coal during 2015-16. This performance was made possible through better planning and monitoring of mining projects, increase in productivity, and better utilization of machinery and commissioning of new projects. In near future CIL will be concentrating on underground mining. In 2013-2014, 34.357 MT of coal was produced by CIL from underground mines. Continuous miners are being used for enhancing production in Tandsi underground coal mine of Kanhan Area of Western Coalfields Limited in difficult roof condition. In this paper the layout of the mine was studied and the support system was also considered. To meet the demand from underground coal production, more mines in India should install continuous miner systems and thereby improve both production and productivity. But detailed analysis of the layout and support system should be done beforehand as this has not been as successful as expected especially in Tandsi seams. There were numerous bottlenecks in the system.

INTRODUCTION

Coal is the most important source of energy for electricity generation in India. Coal India Limited (CIL), a public sector coal company of the Ministry of coal, has reported the highest ever production of 538.75 MT of coal during 2015-16 which is 44.52 MT more compared to 2014-15. So it is showing a production growth of 9%. That was the highest ever increase in coal production. Production of 2014-15 was 494.23 MT (Ministry of Coal 2016). This performance was made possible through better planning and monitoring of mining projects, increase in productivity, and better utilization of machinery and commissioning of new projects. Productivity is measured in terms of raw coal output in tonnes per man-shift (OMS). There has been substantial improvement in OMS in CIL group of Coal Companies during the last decade (Hekimoglu and Ozdemir 2004). As against an OMS of 0.58 tonnes at the time of nationalization, OMS in Coal India Limited during 2014-2015 was 6.05 tonnes and 6.65 tonnes in 2015-16 (provisional). In SCCL the OMS during 2002-2003 was 1.89 tonnes and during 2014-2015 was 4.20 tonnes. This change in productivity was possible by mechanization. Now CIL will be concentrating on underground mining. In 2013-14, 34.357 MT of coal was produced by CIL from underground mines. Technology wise coal production (in Mt) of CIL in 2013-14 was as follows:

1. Bord and Pillar Method
   1. a. Drill-Blast
      - Intermediate technologies with side discharge loaders – 14.74
      - Intermediate technologies with load haul dump machine – 16.77
2. Continuous miner technology – 2.42
3. Longwall / Shortwall technology – 0.057
4. High wall technology – 0.37

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Continuous miners are being used for enhancing production from underground coal mines. At present CIL uses continuous miners in eight underground projects with a total capacity of 3.35 MT a year. CIL is introducing continuous miners with a total capacity of 13.5 MT in 19 more mines. In addition, introduction of continuous miners in nine more mines with a total capacity of 10 MT is under consideration (Bose 2015). Continuous miner playing a major role in the underground coal mining industry due to their safety as well as high productivity. Regarding past experiences in Indian coalfields, Chirimiri and Jhanjra mines have achieved exceptional performances, with a production of 5,00,000 tonnes per year. Tandsi mine has difficult roof conditions and does not typically achieve high production and productivity. The difficult roof conditions have been controlled with proper roof bolting systems and an output of 1200 tonnes per day has been achieved. There are many mines in India that may have potential and economic viability with proper ground control technology concepts for installing continuous miner systems. In Tandsi Mine of Kanhan Area of Western Coalfields Limited continuous miner was installed to meet the demand for coal.

OBJECTIVE

1. To study the layout in a mine where continuous miners have been installed in India with difficult roof condition.

2. To study the support system in an underground coal mine where continuous miner is in operation with difficult roof conditions.

GENERAL INFORMATION ABOUT THE CONTINUOUS MINER

Room and Pillar mining technique with continuous miners is the pre-dominant technology used in underground coal production. Room and Pillar mining method falls in the category of open stopping method and is often used to excavate horizontal deposits with reasonably competent roof strata. A typical continuous miner is shown in Figure 1**.** A continuous miner section is equipped with a continuous miner, 2-3 shuttle cars, a roof bolter and a scoop for auxiliary jobs. The continuous miner extracts the coal from a heading, while the roof bolter installs roof bolts in the immediate excavated heading. Shuttle cars work in tandem with the continuous miner and load the coal on to the feeder breaker arrangement which in turn loads the material on to a conveyor which is usually a high capacity conveyor (Burgess-Limerick and Steiner 2013). As shuttle cars are operated electrically the cables restrict the flexibility and hence the optimal routes should be considered. The out bye transport system should be made of suitable capacity so that the output is optimised.

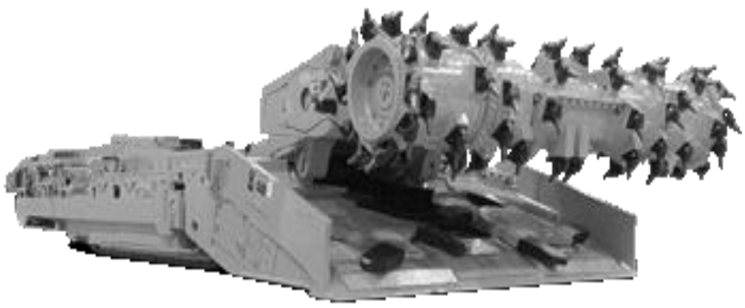

Figure: 1 Continuous miner

Typical specifications of Joy 12CM continuous miner are:

- Length of the continuous miner is about 16.5 m
- Capacity of cutting is around 1000 t / hr.
- Weight of the continuous miner is around 75 t.
- Mining height ranges from 1.56 -3.76 m.
- Cutting power of the continuous miner is around 2 x 245 kW.

- Total power of the continuous miner being around 750 kW, including pump, gathering head and Traction.
- The ground pressure of the continuous miner is around 234 kPa.

The supporting is usually done with ‘spin to stall resin bolting’ using quad bolter or the so called multi-bolter as shown in Figure 2, in tandem in the entry which has been worked out (Singh 1998). The multi-bolter/quad-bolter has a twin boom with four bolting rigs.

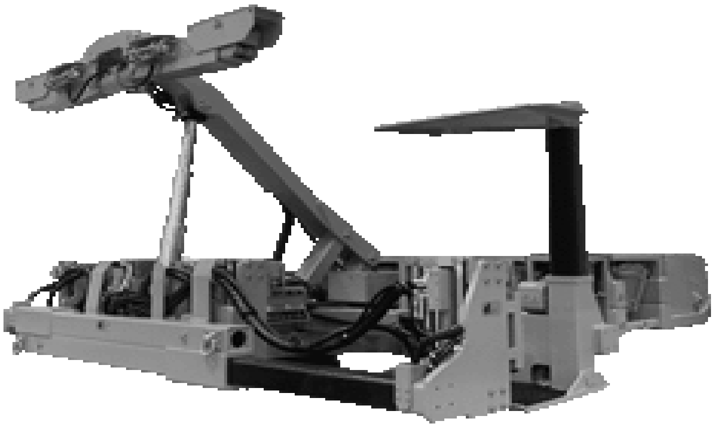

Figure: 2 A typical Joy Quad bolter (Multi-bolter)

Typical specifications of the multi-bolter is:

- Height of the multi-bolter ranges from 2.4 m - 4.7 m.
- Drill rigs feed around 25 m / min for drilling holes for roof bolting.
- Drill motor torque is around 384 Nm (max).
- Weight of the multi-bolter is around 30 t.
- Power of the multi-bolter is around 112 kW.

The continuous miner extracts coal in around two pass operation which means it changes its position to cut the full width of the entry (around 5-6 m). The length of the cut (6 to 12 m) varies depending on the roof conditions as well as the ventilation requirement and the features of the continuous miner.

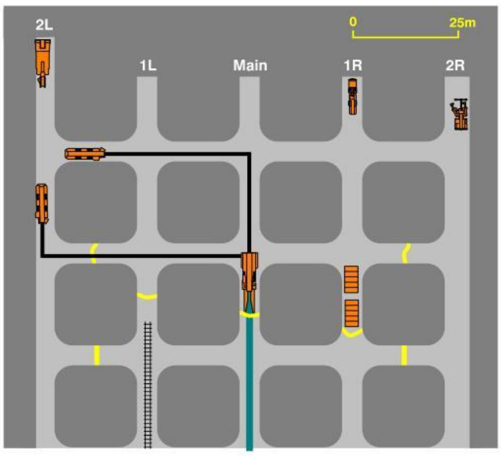

Figure 3: Five heading mechanized continuous miner layout

Five heading mechanized continuous miner layout is shown in Figure 3. In this technology, mining takes place by place changing system. Five heading panel is optimum. The Continuous miner cuts and load coal to shuttle car at a place. For developing full width of Gallery, continuous miner cuts in two passes at a place. The shuttle car hauls the load to the feeder breaker. Feeder breaker feeds sized coal to the gate-belt conveyor at a consistent rate. After completing a cut of desired length (cut-out length) continuous miner moves out of the place and the roof bolter moves in for roof bolting. Same sequence of operation is repeated at another place. A typical cutting sequence for development Panel and depillaring panel is shown in Figure 4 and Figure 5 respectively.

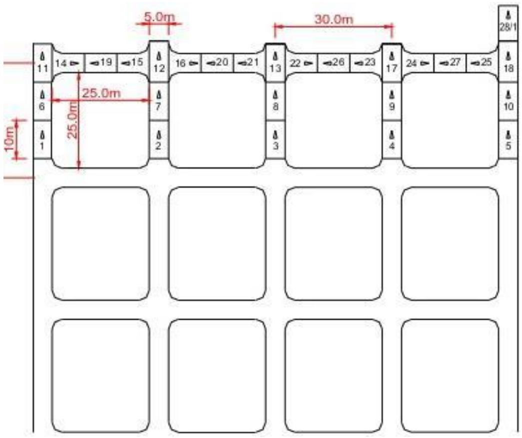

Figure 4: A typical cutting sequence for development panel

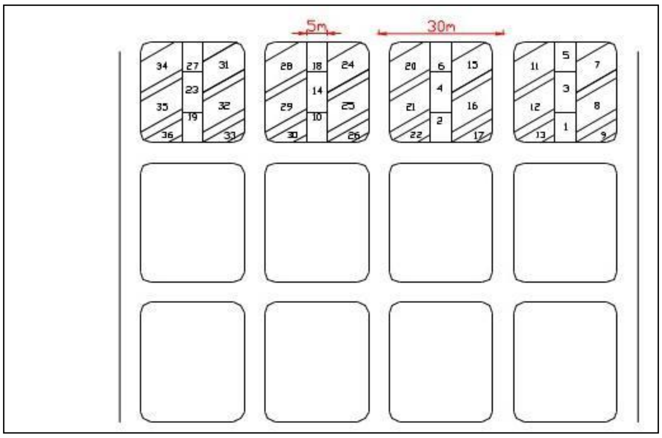

Figure 5: A typical cutting sequence for depillaring panel

ADVANTAGES AND DISADVANTAGES OF CONTINUOUS MINER

The basic advantages of working with continuous miner are as follows:

- The production in this case is higher which should be matched by suitable out-bye transport system.
- Mechanised system, so no problem or delay in work.
- OMS higher as production and productivity greater.
- No drilling blasting required as cutting of coal done using the continuous miner.
- Loading usually done by shuttle car followed by haulage transport system thus it is much faster.

The basic disadvantages of continuous miner are as follows:

- The continuous miner cannot work in a watery seam.
- Strata condition is to be good as it requires a good gallery width.

- In place of normal rectangular pillar, round corner pillars are required.
- It is also not suitable for undulating floor.
- Good out-bye matching transport is required with high capacity shaft/skip arrangement to take coal to the surface.

Thus continuous miner installed in number of collieries has worked with relative success at some of the mines in Western Coalfields Limited and South Eastern Coalfields Limited as well in S.C.C.L.

CASE STUDY REGIONS

The case study region selected is Tandsi Mine of the Kanhan Area in Western Coalfields Limited – a subsidiary of Coal India Limited.

DETAIL LAYOUT AND METHOD OF WORKING

The mine there is being worked by Bord and Pillar method in which continuous miners are being used as the main equipment for extracting coal. The Pillar size which is being kept for support of the overburden pressure is 35 m x 35 m, 40 m x 40 m and 40 m x 35 m. The depth of cover above the seam varies between 220 m to 400 m. The gallery width being used for continuous miner production is 3.6 x 2.7 m; 4.8 m x 2.7 m and 4.8 m x 3.5 m. This roof of the mine is usually of sandstone but the presence of cross-bedded layers and joints, which cause immediate roof collapse, resulting breakage which varies from 4 m to even up to 8 m deep into the roof.

The coal present in the mine is soft Bituminous coal. The problems faced by the mine is usually heavy strata control problems which has resulted in these roof falls and thereby reduce the average production per day to less than 500 t. The mining potential of this mine is seriously affected.

The production seen with the continuous miner did not reach 500 tonnes/day average production and hence the mine incurred heavy losses. The production with continuous miner in the year 2002-2003 was around 50900 t and in 2003-04 was around 192 400 t. Figures 6 - 8 show various layouts.

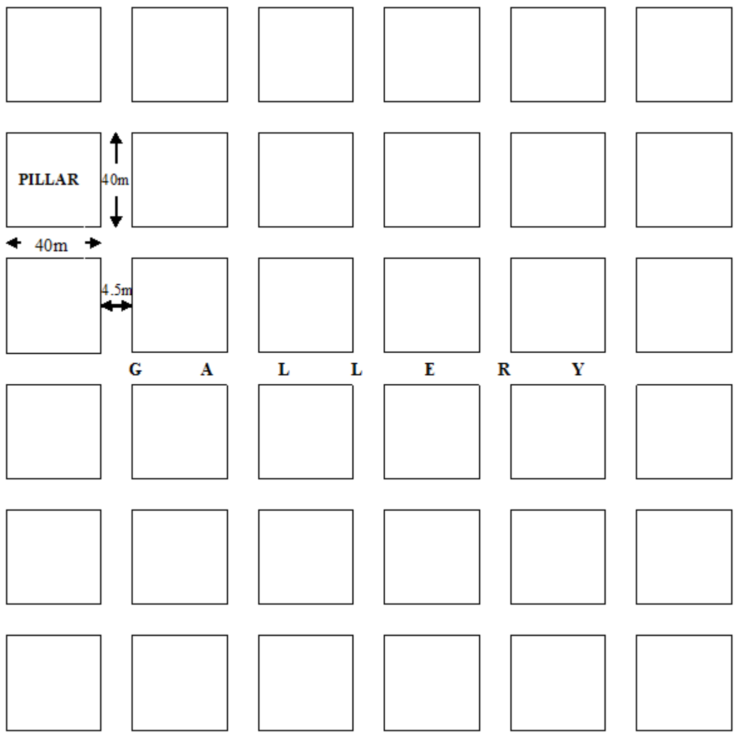

Figure 6: Layout No.1

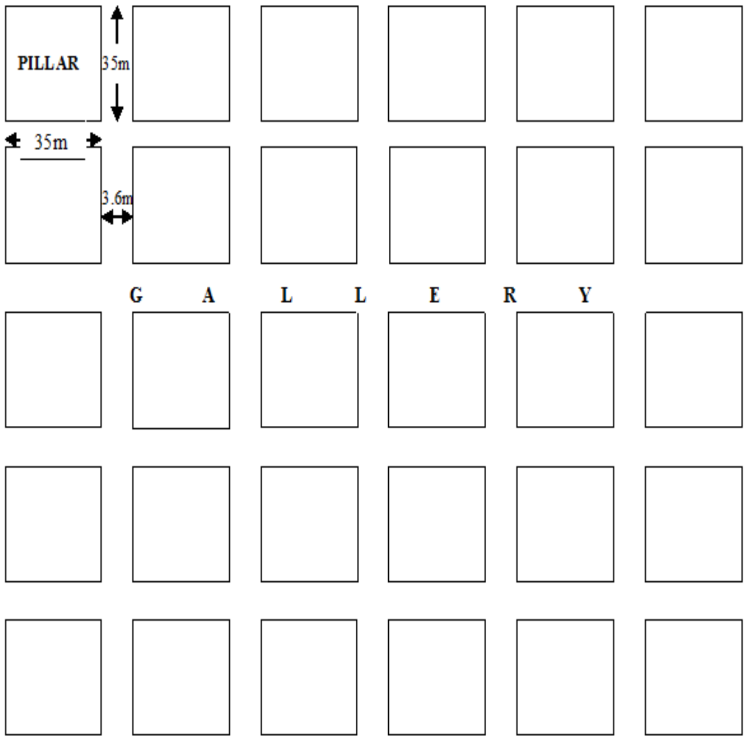

Figure 7: Layout No.2

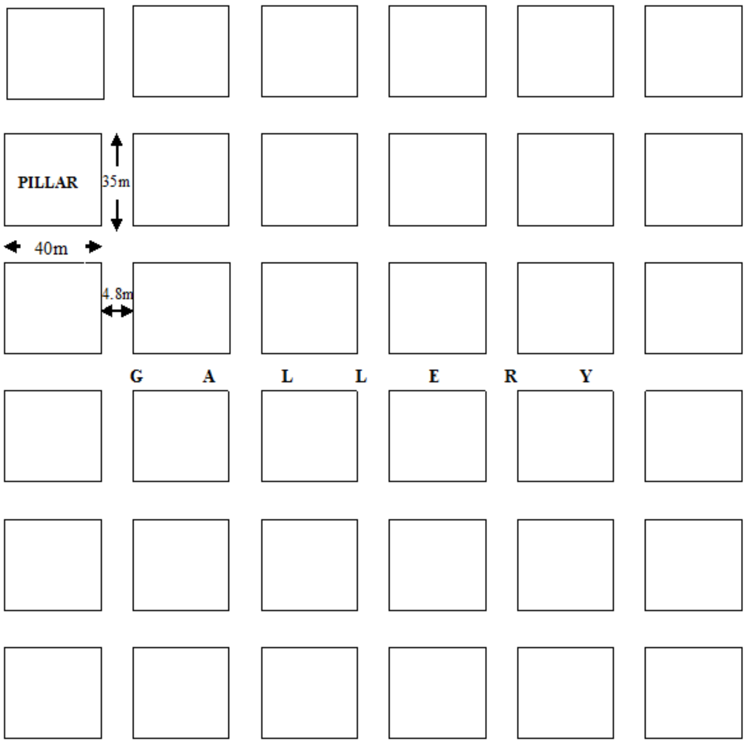

Figure 8: Layout No.3

SUPPORT SYSTEM

The main cause of low production was geologically disturbed strata conditions. Roof cracks were observed at the early stages of development and hence this resulted in roof falls at many places. The roof in the case of Tandsi Mine was having a Rock Mas Rating (RMR) of 44-64. The roof was supported by using roof bolts up to 1.5 m in length and using spin to stall resin bolting using cement capsules.

As shown in Figure 6 (Layout no.1), the system initially designed to support the roof for a gallery width of 4.5 m and the height of the gallery being 3.0 m. The roof bolting system (1) in this case is shown in Figure 9. The roof bolts were installed such that there were three bolts in each row. These had a space of 1.5 m among each other and 0.75 m from the pillar. One of the bolts was drilled vertically. And the other two were so drilled that they were inclined in such a way that they went into the pillar there by supporting the overburden pressure. This resulted in heavy roof fall, resulted in changing the support design which can hold the roof better.

Due to failure of the above pattern a new layout as shown in Figure 7 (Layout no: 2) was developed in which the gallery width was reduced to 3.6 m and the height was kept constant at 3.0 m. The roof bolting system (2) was also changed as shown in Figure 10. In this case also we had three bolts which were installed in a row. One of the bolts was drilled in vertically upwards and the other two were drilled in, an inclined direction into the side of the pillar. The spacing between the bolts was kept at 1.5 m and the distance between the side pillar and the bolts was 0.3 m. But this modified design also resulted in roof falls.

At the colliery level the support design was further modified as shown in Figure 11. In this design the number of holes in each row was further increased. Corresponding layout design was shown in Figure 8 (Layout no.3). The gallery width was kept constant at 3.6 m width and 3.0 m height. The supports increased to 4 roof bolts. The distance between the holes being kept at a distance of 1.0 m each and the distance between the bolts and the pillar being kept at 0.3 m distance. The 2 bolts being drilled in were drilled in vertically and the other two were kept inclined at an angle and drilled at the side into the pillar. Roof falls being prevented to an extent and this layout was finally adopted.

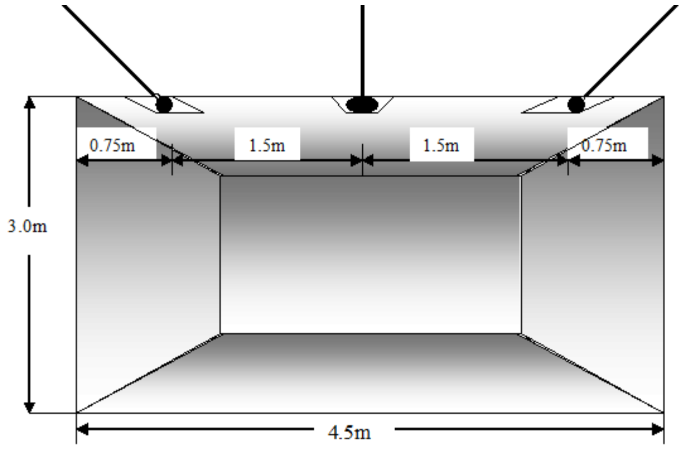

Figure 9: Support system design (1)

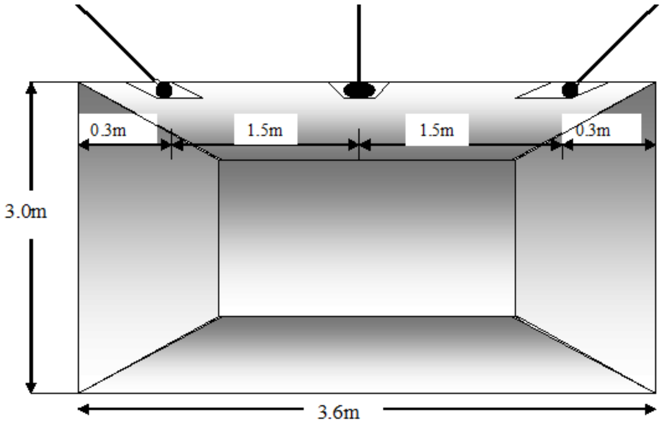

Figure 10: Support system design (2)

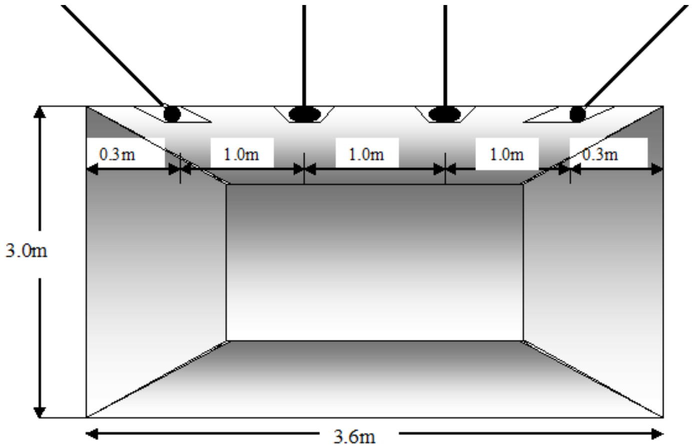

Figure 11: Support system design (3)

CONCLUSION

To meet the demand from underground coal production, more mines in India should install continuous miner systems and thereby improve both production and productivity. Some underground mines of Coal India Limited have achieved exceptional performances whereas some mines of Western Coalfields Limited have difficult roof condition.

The difficult roof condition have been controlled with proper roof bolting technology and output up to 1200 tonnes per day have been achieved. But detailed analysis of the layout and support system should be done beforehand as this has not been successful as expected especially in Tandsi seams. There were numerous bottlenecks in the system, which have to be addressed. Roof condition was one of the major problems which have been partially addressed. The correct implementation of these systems would make a significant impact upon safety as well as providing a major increase in production and productivity in underground coal mines.

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